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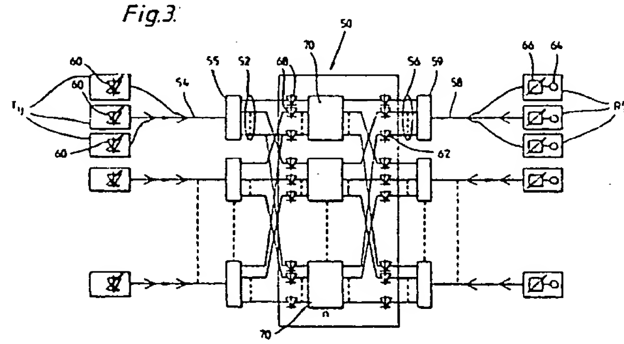
(54) **Communications network.**

(57) A communications network in which a central switching node (70) has at least two sets of both input ports (52) and output port (56) coupled to respective sets of transmitters (T_{ij}) and receivers (R_{ij}) by passive optical networks (54) and (58) and demultiplexers (52) and multiplexers (59). The transmitters (T_{ij}) are tunable so that each can be selectively coupled to one of the input ports (52). The receivers (R_{ij}) are also tunable so the output ports (56) can be selectively coupled to the one or more of the receivers (R_{ij}). Alternatively, the demultiplexers (55) and multiplexers (59) can be tunable. This devolves some of the switching function outside the central switching node (50) thereby reducing the component count.

Fig.3.



EP 0 382 431 A1

COMMUNICATIONS NETWORK

This invention relates to communications networks and in particular to networks in which the transmitters of two or more sub-networks of transmitters are connectable to receivers of two or more sub-networks of receivers by means of a central switching node.

In a known implementation of such a network the transmitters and receivers are linked to the input and output ports of the central switching node by means of dedicated electrical communications links the node having sufficient switching power to be able to interconnect a desired number of ports.

Passive optical networks are emerging as a promising means of providing customers with broadband services, and are economically attractive for providing telephony and low data-rate services to customers requiring just a few lines. The telephony passive optical network (TPON) shares customer access costs by means of a passive splitting architecture to multiplex up to 128 customers, with current technologies, onto a single fibre at the exchange. With such a network in place, broadband services could easily be provided by the addition of more operating wavelengths. The first step towards a broadband passive optical network (BPON) would probably be to add just a few wavelengths, each allocated to a particular service such as broadcast TV, video library and ATM services, with each wavelength electronically multiplexed to provide sufficient numbers of channels. In the longer term, spectrally controlled sources such as DFB lasers would allow extensive wavelength multiplexing, and the possibility of allocating wavelengths to individual customers or connections, to provide wavelength switching across the network.

It has therefore been proposed to link the sub-networks of transmitters and receivers to the central switching node by means of such passive optical networks in which each transmitter of a sub-network transmits information optically on an optical carrier of a fixed, distinct wavelength, the various transmitted signals being passively multiplexed onto a single optical fibre for transmission to the central switching node. A demultiplexer at the central switching node would separate the signals according to wavelength and convert each into an electrical signal. In this way each transmitter is permanently linked to a distinct, input port of the central switching node. Similarly, the outgoing connections from the output ports of the central switching node to the optical receivers can be in the form of a passive optical network. The outgoing signal from each output port of the central switching node is converted to an optical signal of a wavelength corresponding to that which the receiver associated with that output port is configured to receive. These optical signals for the receivers of the sub-network are multiplexed onto a single outgoing optical fibre which multiplex is passively split to each receiver. Each receiver selects the wavelength corresponding to it by the use, for example, of an optical filter or a coherent optical receiver. Such a network employing passive optical sub-networks requires a central node of the same switching power as that using dedicated electrical connections for the same interconnect power.

Another known interconnection arrangement uses wavelength switching or routeing which is a simple but powerful technique for providing both one-to-one and broadcast connections between customers. One-to-one connections simply require each customer to have a tuneable light source connected by a wavelength division multiplexer. Light can be directed from any transmitter to any receiver by tuning to an appropriate wavelength. A fast connection time of 2 nsec. has been demonstrated using a cleaved coupled cavity (C^3) laser. Broadcast or distributed connections are naturally provided by a star coupler arrangement shown, for example, in patent application EP-A-2,043,240. A star coupler splits the optical power from each input port to every output port so that by using sources of fixed, distinct wavelengths, appropriate channels can be selected at the receivers by means of tuneable optical filters. This has been demonstrated using an 8x8 array of wavelength-flattened fused-fibre couplers and position-tuneable holographic filters recorded in dichromated gelatin, to tune across the entire long-wavelength window from 1250-1600 nm. An acousto-optic tuneable filter has more recently been demonstrated with about 1nm bandwidth, 260 nm tuning range and a channel selection speed of 3 microseconds.

In common with optical space switches, use of wavelength switching in the local network would enable the full potential of optics to be realised, by providing a broadband optical switching and distribution capability, which is essentially transparent to the chosen signal bandwidth and modulation format. A large number of diverse optical technologies have been identified for achieving both space and wavelength switching in a local network environment.

However, both switching techniques have their limitations and disadvantages. For space switches, it is the sheer number, and hence cost, of crosspoints or equivalent switches needed to interconnect customers (from information theory the minimum growth rate that can be incurred is $\log_2(N!)$).

For wavelength switches the problem is the limited number of available distinct wavelength channels, which restricts the number of customers, although this limitation can be overcome by employing wavelength switches in three or more stages of switching which allows the same wavelengths to be re-used in different "switches". For space switches, the use of multi-stage networks can never overcome the $\log_2(N!)$ growth rate.

A communications network according to the present invention comprises a central switching node having at least two sets of input ports and at least two sets of output ports;
each set of input ports being coupled to a respective set of optical transmitters by an input connection means cooperable with the transmitters to selectively couple each transmitter to at least any one selected input port; and
each set of output ports being coupled to a respective set of optical receivers by an output connection means cooperable with the receivers to selectively couple each output port to at least any one receiver.

Preferably the input connection means comprises an optical fibre sub-network for passively multiplexing signals from the respective set of optical transmitters into an input multiplex of transmitter channels and an input demultiplexing means for coupling each channel of the multiplex to a respective input; and the output connection means comprises an input multiplexing means for passively multiplexing signals from the respective set of outputs into an output multiplex of receiver channels and an optical fibre sub-network for coupling the output multiplex to the respective receivers.

The architecture of the present invention can provide significant reductions in component quantities by distributing some of the switching task away from the central switching node to the connection means rather than using the conventional approach of performing all the switching centrally in the exchange. The switching task is then separated into three stages, with the first and third stages implemented, for example, as multiplex switches operating in a distributed manner in the external sub-networks connecting the central switching node to the transmitters and receivers. Only the middle stage of the switch is located in the central node or "exchange". The middle stage can be implemented either in the form of space switches or wavelength switches.

The connections between transmitters and input ports can be achieved by providing that each transmitter is controllable to transmit signals on a channel corresponding to the input port to which it is to be selectively coupled or that the input demultiplexing means is controllable to couple the signals on each channel to a selected input port.

The connections between output ports and receivers can be achieved by providing that the receivers are controllable to receive signals on a channel corresponding to the output port to which it is to be selectively coupled or that the output multiplexing means are controllable to form an output multiplex of signals on those channels such that each output port is coupled to a selected receiver.

Preferably the multiplexes are wavelength multiplexes in which the selectivity is achieved by means of frequency selective devices, for example on the input side tunable lasers at the transmitters or frequency selective filters at the input ports, and on the output side passive splitting to tunable filters at the receivers or fixed filters at the receivers with tunable lasers in the multiplexing means.

Other multiplexing techniques may be employed, for example time domain multiplexes, the coupling of transmitters and receivers to respective input and output ports being achieved by altering the time slot to which transmitters and receivers are allocated or by controlling the demultiplexers or multiplexers at the input and output ports, the transmitters and receivers being allocated to dedicated time slots.

The network according to the present invention reduces the switching power needed at the central switching node for a given interconnect power by devolving some of the switching function to the sub-networks. For example, in the case where wavelength multiplexing is employed by controlling the wavelength on which the optical transmitters transmit their signals to the central node, it is possible to selectively route the signals to any of the input ports of the set by controlling the wavelength of the transmissions. Similarly, by controlling the wavelength which the optical receivers receive, the optical signals from the output ports of a set of output ports can be selectively routed to any one of the corresponding set of optical receivers. Similarly, if the optical transmitters and receivers transmit or receive a fixed wavelength the demultiplexers at the input ports or the multiplexers at the output ports can be made tunable to effect the switching between transmitters and receivers and the input and output ports, respectively, of the central switching node.

The present invention also has advantage of allowing concentration, that is the use of fewer multiplex channels, for example wavelengths, with a sub-network than there are optical transmitters or optical receivers by allocating the available channels dynamically to those wishing to transmit or receive at a given time.

Embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram of a prior art communications network; and

Figure 2 is a schematic diagram of a further prior art communications network using passive optical networks to link transmitters and receivers with a central exchange;

Figure 3 is schematic diagram of a communications network according to the present invention, employing tunable transmitters and receivers and central space switching.

Figure 4 is a graph comparing of the optical crosspoint requirements for centralised space switching and wavelength/space/wavelength switching according to the present invention;

Figure 5 is a schematic diagram of a communications network according to the present invention employing tunable transmitters and receivers and wavelength switching in the central node;

Figure 6 is a graph comparing the optical cross point requirements for centralised switching and wavelength/wavelength switching according to the present invention;

Figure 7 is a schematic diagram of an experimental embodiment of the present invention employing several optical technologies; and

Figure 8 is a graph showing the selection of two adjacent channels from twelve by the embodiment of Figure 6.

Referring to Figure 1 an exemplary prior art communications network comprises a central switching node 2 having two sets of input ports 4 and 6 with input ports I_{1j} and I_{2j} respectively and two sets of output ports 8 and 10 with output ports O_{1j} and O_{2j} respectively.

Two groups of optical transmitters T_{1j} and T_{2j} are directly connected to the correspondingly subscripted input port I_{ij} i = 1 or 2 by a respective input connection means formed by transmitter sub-networks 12 and 14, respectively.

Similarly, each output port O_{ij} of the two sets of output ports 8 and 10 is directly coupled to a correspondingly labelled receiver R_{ij} by a respective receiver sub-network 16 and 18.

The central switching node 2 is provided with sufficient switching power to achieve the required degree of interconnectivity between the transmitters T_{ij} and receivers R_{ij} the details of which are not shown.

If switching in a future optical local network were to be undertaken in the same way, i.e. to transport customer signals to a central node or exchange where all the interconnection equipment is located, shared access over the passive network could be achieved by multiplexing in any of the time, frequency or wavelength domains. To make the maximum broadband capacity available to customers, the wavelength domain is preferred.

Figure 2 shows the physical structure of a large, optical local network, employing passive wavelength division multiplexing techniques to transport broadband channels to and from each customer which is arranged to interconnect the same number of transmitters and receivers as the communications network of Figure 1, the identical elements being indicated by the same designation as in Figure 1. All switching is, again performed in the central switching node 2.

In the network of Figure 2, each transmitter T_{ij} is an optical transmitter transmitting optical signals at a particular one of various distinct wavelengths each corresponding to a communication channel. The optical outputs from the transmitters T_{ij} are passively multiplexed by subnetworks 20 and 22 onto single fibres 28 and 30 coupled to a corresponding demultiplexer 32 and 34 which couples optical signals of a given wavelength to a corresponding one of the ports I_{ij}. Each transmitter T_{ij} is therefore permanently coupled to a distinct one of the input ports I_{ij}.

Each receiver R_{ij} is a wavelength selective optical receiver. Each output port O_{ij} of the sets of output ports 8 and 10 transmits an optical signal at a distinct wavelength which signals are passively multiplexed onto a single optical fibres 36 and 38 by multiplexer 40 and 42, respectively, which may be formed by passive optical couplers, for example. The wavelength multiplex is passively coupled to each wavelength selective receiver R_{ij} each of which selects the wavelength channel to be received. Each receiver R_{ij} is therefore permanently coupled to a distinct one of the output ports O_{ij}.

The Figure 2 network shows simplex operation with upstream and downstream directions carried over different passive limbs. The principle can be extended to duplex, single-sided operation. Regenerators and lasers (not shown) can be used in known manner to recover the signal level either side of the central switch node 2, to accommodate losses in the switch. Alternatively optical amplifiers could be used on the input side of the switch, but not in general on the output side, where wavelength translation may be needed. Although a suitable wavelength converter would make use of non-linear effects in optical amplifiers. The central exchange 2 can be implemented either as a multi-stage space switch or as a three-stage wavelength/wavelength/wavelength switch.

There are many potential technologies and architectures for implementing optical space switches in the central exchange. But perhaps the solution requiring the least components, and offering the lowest loss, is a multi-stage rearrangeable network. Studies have shown that very large switches could be built with these structures, using crosspoints of only modest crosstalk performance. Mean losses of 1 dB per crosspoint in a two-sided switch could

yield sizes of 32,768x32,768 with a 29 dB power budget. The number of crosspoints required to connect N inputs to N outputs with these networks is

$N\log_2(N)-N+1$ (1)

which is very close to the information theory limit $\log_2(N!)$.

If the central exchange 2 of Fig. 2 is to be implemented by wavelength switching techniques, there are unlikely to be sufficient wavelength channels for the switching to be achieved in a single stage. Generalising the network of Figure 2 to have N customers in sets of n transmitters and receivers coupled to sets of n input and output ports by $^N/n$ passive optical networks the total number of wavelength multiplexers required is

$\frac{2N}{n} + \frac{2N}{m} + m$ (2)

To minimise this quantity, there is an optimum number of tuneable lasers per switch, namely:

$m = (2N)^{1/2}$ (3)

which for N = 8192 is 128 (which is greater than the probable broadband split size of about 32). The minimum possible number of multiplexers is therefore

$2N/n + 2(2N)^{1/2}$ (4)

Referring now to Figure 3, a communications network according to the present invention is shown for interconnecting N customers divided into n sets. It comprises a central switching node 50 having $^N/n$ sets of input ports 52, a respective set of transmitters T_{ij}, the transmitters T_{ij} being coupled to the input ports of the central node 50 by a passive optical sub-network 54 via a wavelength demultiplexer 55 constituting the input connection means. Only one input sub-network is numbered for clarity. There are also $^N/n$ sets of output ports 56 each coupled to a respective set of optical receivers R_{ij} by a passive optical network 58 via a wavelength multiplexer 59 constituting the output connection means, again only one output sub-network being numbered for clarity.

The demultiplexer 55 distributes optical signals received from the sub-network 54 to the input ports of the set 52 according to their wavelength, one wavelength being associated with each of the ports. The tunable lasers 60 of the transmitters T_{ij} can be tuned to the wavelength appropriate to the input port of the set 52 which it is to be coupled.

The transmitters could incorporate other tunable sources, for example a broadband optical source coupled to the sub-network 54 via a tunable optical filter.

Signals from output ports of the set 56 each have associated with them a distinct wavelength determined by the fixed wavelength lasers 62. These optical signals are multiplexed onto the single optical fibre 58 and passively split to the receivers R_{ij}. Each receiver R_{ij} comprises an optical receiver 64 and a tunable optical filter 66. The receivers R_{ij} select the output to which they are to be coupled by tuning the optical filter to the appropriate wavelength.

The central switching node, or exchange, 50 is a known second-stage optical space switching node having fixed wavelength lasers 68 and space switches 70.

It will be appreciated that devices other than tunable lasers and tunable filters may be employed to achieve the selection of the wavelengths to be transmitted and received by the transmitters T_{ij} and receivers R_{ij}.

The devolution of some of the switching power to the wavelength controllable optical transmitters T_{ij} and receivers R_{ij} allows simplification of the central switching node whilst retaining the same interconnect power for the following reasons.

The number of crosspoints needed in the exchange 50 is reduced by removing the first-and third-stage switches out into the passive networks, as wavelength switches. This allows the tunable lasers 60, input demultiplexers 55 and output multiplexers 56 and tuneable optical filters 06 to be used simultaneously for both transmission, reception and switching tasks in the local loop. Only the middle stage of space switches are required at the exchange 50. With the passive networks providing nxn switches (n being the split size of the passive networks), then if we assume that the n middle-stage switches are constructed as rearrangeable switching networks, the minimum number of crosspoints required is

$n[(N/n)\log_2(N/n)-N/n+1] = N\log_2(N/n)-N+n$ (5)

Equations (1) and (5) are plotted in Figure 4 for an n = 32 way split. It can be seen that distributed switching provided by the present invention offers large reductions in the numbers of optical crosspoints required. For a network of 8192 customers and a split size of 32 only 58% of the crosspoints in a centralised space switch would be needed. Greater savings could be made with larger passive split sizes, which could be achieved by the use of optical amplifiers.

Referring now to Figure 5 a distributed wavelength/wavelength/wavelength embodiment of the present invention shown.

The subnetworks are common to the embodiment of Figure 3, the same parts having the same reference numerals. The space switching node 50 of Figure 3 is replaced by a wavelength switching node 70 including tunable lasers 72 coupled to the sets of input ports 52 and wavelength multiplexer 74 for carrying out the switching in the wavelength domain in a known manner.

Removal of the first-and third-stage wavelength switches out into the passive networks reduces the laser and regenerator quantities to 3 per connec-

tion instead of 5, and reduces the number of wavelength multiplexers to just three stages, with 2N/n in the passive limbs and a further n in the middle stage.ie

2N/n + n (6)

wavelength multiplexers overall. Although there is an optimum split size n to minimise this quantity (n_{opt} = 128 for N = 8192), the realistic split size of 32 is used in Figure 6 to compare equations (4) and (6). While the reductions in wavelength multiplexer quantities provided by distributed switching would of course be beneficial, their costs are shared between many customers (15 for N = 8192, n = 32), so these savings will probably not be as important as the 40% reduction from 5 lasers and regenerators per customer back to the minimum quantity of 3, needed to achieve any form of broadband switching in the spatial or wavelength domains.

Referring to Figure 7 a small network built to demonstrate the principle of the distributed wavelength switching of the present invention in a passive local network is shown. The wavelength/space/wavelength architecture of the type shown in Figure 6 was chosen to demonstrate the combined use of both space and wavelength switches. The network has 6 passive optical "limbs", 3 upstream (80, 82 and 84) and 3 downstream (86, 88 and 90).

The optical limb 80 passively multiplexes optical signals at distinct wavelengths λ_1 and λ_2 from lasers 92 and 94 onto a 2.2km single optical fibre 96. A 20 channel wavelength multiplexer 97 was used to simulate the coupling of many different wavelengths onto a single fibre. Twelve DFB lasers were multiplexed at 3.6nm intervals in the 1500mm window by the lasers (not shown). The multiplex is then coupled to each of the two input ports of the set 92 via respective optical filters 98 and 100 which demultiplex the received multiplex so one wavelength channel is received at each of the input ports. Each laser 92 and 94 can be coupled to either input port by tuning the optical filter to the appropriate wavelength.

Sub-networks 82 and 84 provide two inputs to pairs of inputs 102 and 104 by means of a 4-port optical coupler 106 and a 2x8 coupler 108 respectively, to passively multiplex signals to optical filter demultiplexers as used in subnetwork 90.

The sub-network 86 has a passive optical fibre coupler 106 which multiplexes the optical signals from output ports 108 and 110 at two distinct wavelengths λ_5 and λ_6 onto the single 2.2km long optical fibre 112. The output multiplex is coupled to receivers 114 and 116 via tunable optical filters 118 and 120 respectively which allow each port 108 to be coupled to a selected receiver or receivers 118 and 120.

Sub-networks 90 has a 1x7 monolithic coupler 122 to simulate a 7-way branching passive network. Sub-network 88 provides a sub-network without a single optical fibre portion by means of a 4 port passive optical coupler 124. The channel selection in sub-networks 88 and 90 is by the same means as described above in relation to links 86. Because fixed-wavelength DFB sources are used, rather than tuneable lasers, the routeing tasks of the wavelength demultiplexers in the first stage of switching of Figure 3 are obtained by means of fused-fibre couplers, followed by additional tuneable optical filters to select the correct wavelength channels. The tuneable optical filters employ a compact disc focussing coil to move an optical fibre in a dispersive imaging system, thus selecting any wavelength across the range 1250-1600 nm, with a half-power bandwidth of 2.6 nm.

There are just two middle-stage space switches 124 and 126, each of size 3x3, so that a 6x6 network can be demonstrated overall. Each 3x3 switch 124 and 126 is constructed as a rearrangeable switching network (RSN), using 3 commercially available, single-mode 2x2 changeover switches (not shown).

Figure 8 shows two adjacent DFB laser wavelengths being selected by a filter from the twelve multiplexed channels. The coupling tasks of the wavelength multiplexers in the third stage of switching in Figure 3 are also undertaken with fused-fibre couplers. In this small demonstration network, there is no need for a third set of regenerators and lasers prior to the space switches.

Several key features of the distributed architecture are of particular importance. Firstly, the concept of re-use of the same set of wavelengths in the different passive limbs. To demonstrate this, the lasers in limb 80 have essentially the same wavelengths λ_1 and λ_2 as those in limb 84. Having identical sets of wavelengths in each first-stage switch like this requires a second feature, namely that wavelength conversion must take place before signals enter the third-stage switch (passive network) lest two identical wavelengths couple together there. Although direct wavelength translation devices might one day perform this task, it has been achieved here by simple regeneration to an electrical signal followed by re-emission from a new laser. Two signals at identical wavelengths, one from limb 80 and one from limb 84, can be switched through separate middle-stage space switches to outputs on the same third-stage limb.

An important feature of the architecture of the present invention is its capability of broadcasting. The power-splitting nature of the third stage makes the passive optical network ideally suited for broadcast (one-to-many) connections. By simply allowing more than one optical filter to tune to the same wavelength simultaneously all the customers on a

limb can receive the same signal. Furthermore, in principle, any transmitter (customer) could become a service provider to any number of customers, by using the same power splitting mechanism in the first-stage switches to produce multiple copies onto the middle-stage switches in the manner of the rearrangeable broadcast networks. In such networks the middle-stage switches would also need to possess a broadcasting function, which can easily be fulfilled by the wavelength/wavelength/wavelength distributed architecture and which needs only slight modification of the space switches in the wavelength/space/wavelength architecture.

In summary, the present invention provides a distributed wavelength switching architecture for passive optical networks. Rather than performing all the broadband switching conventionally in a central exchange, the architecture distributes the first and last stages of switching over the passive optical network sharing the same components already required for transmission purposes. Only the middle stage of switching requires additional components in the exchange. In this way, large savings in component quantities are provided compared with the conventional local network architecture of centralised switching. The principle of distributed switching can be extended to provide a full broadcasting capability from any customer to all others.

Although the benefits of the proposed architecture of the present invention has been discussed for rearrangeably non-blocking switch structures, the invention is also applicable with strictly non-blocking switches.

The present invention is also applicable to bi-directional networks in which case the optical outputs from a set of output ports may be multiplexed to propagate along a transmitter sub-network in which case the one passive sub-network is to be considered for the purposes of the patent application to be form simultaneously a transmitter sub-network and a receiver sub-network.

Claims

1. A communications network comprising:
a central switching node having at least two sets of input ports and at least two sets of output ports;
each set of input ports being coupled to a respective set of optical transmitters by an input connection means cooperable with the transmitters to selectively couple each transmitter to at least any one selected input port; and
each set of output ports being coupled to a respective set of optical receivers by an output connection means cooperable with the receivers to selectively couple each output port to at least any one receiver.

2. A network as claimed in claim 1 in which at least one of the input connection means comprises an optical fibre subnetwork for passively multiplexing signals from the respective set of optical transmitters into an input multiplex of transmitter channels; and
an input demultiplexing means for coupling each channel of the multiplex to a respective input;
each transmitter being controllable to transmit signals on a channel corresponding to the input port to which it is to be selectively coupled.

3. A network as claimed in claim 1 in which at least one of the input connection means comprises an optical fibre subnetwork for passively multiplexing signals from the respective set of optical transmitters into an input multiplex of transmitter channels; and
an input demultiplexing means coupled to the input fibre for coupling each channel of the multiplex to a respective input;
the input demultiplexing means being controllable to couple the signals on each channel to a selected input port.

4. A network as claimed in claim 1 in which at least one of the output connection means comprises an output multiplexing means for passively multiplexing signals from the respective set of outputs into an output multiplex of receiver channels; and
an optical fibre sub-network for coupling the output multiplex to the respective receivers;
the receivers being controllable to receive signals on a channel corresponding to the output port to which it is to be selectively coupled.

5. A network as claimed in claim 1 in which at least one of the output connection means comprises an output multiplexing means for passively multiplexing signals from the respective outputs onto an output multiplex of receiver channels; and
an optical fibre sub-network coupled for coupling the output multiplex to the respective receivers, each receiver being arranged to receive signals of one channel; and
the output multiplexing means being controllable to form an output multiplex of signals on those channels such that each output port is coupled to a selected receiver.

6. A network as claimed in any preceding claim in which the input multiplex and output multiplex are formed onto a single optical fibre.

7. A network as claimed in any preceding claim in which the signals from the sets of transmitters and the sets of outputs are formed into respective wavelength multiplexes.

8. A network as claimed in claim 7 in which the transmitters include wavelength tunable optical sources.

9. A network as claimed in claim 3 in which each transmitter transmits signals of a distinct wavelength, each wavelength corresponding to a channel, and the input demultiplexing means comprises one or more passive optical splitters for coupling the received input multiplex to each input port via a tunable optical filter.

10. A network as claimed in claim 4 in which each receiver includes a tunable optical filter.

11. A network as claimed in claim 5 in which each receivers of each set of receivers is able to receive signals on a respective distinct wavelength and the output multiplexing means includes wavelength tunable optical sources.

12. A network as claimed in any one of claims 1,2,5 and 10 in which the wavelength tunable optical sources comprise tunable lasers.

13. A network as claimed in any preceding claim in which the input connection means and output connection means have an optical propagation path at least in part formed by the same optical sub-network.

Fig.1. PRIOR ART

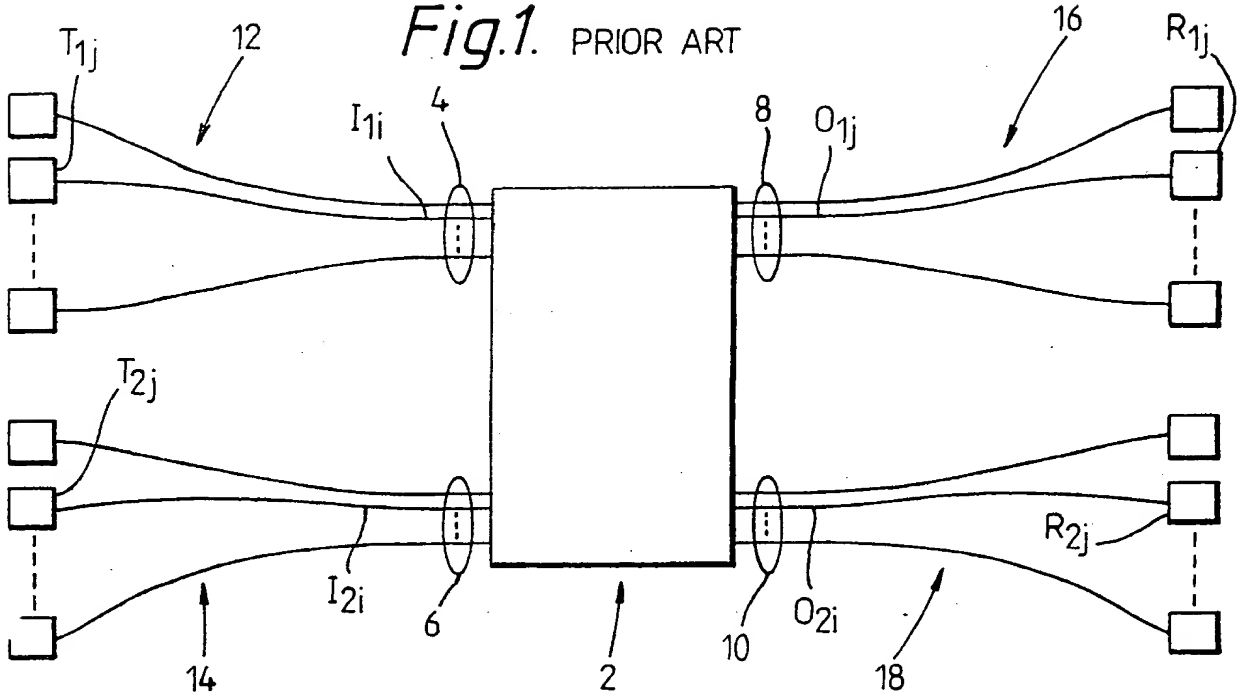


Fig.2. PRIOR ART

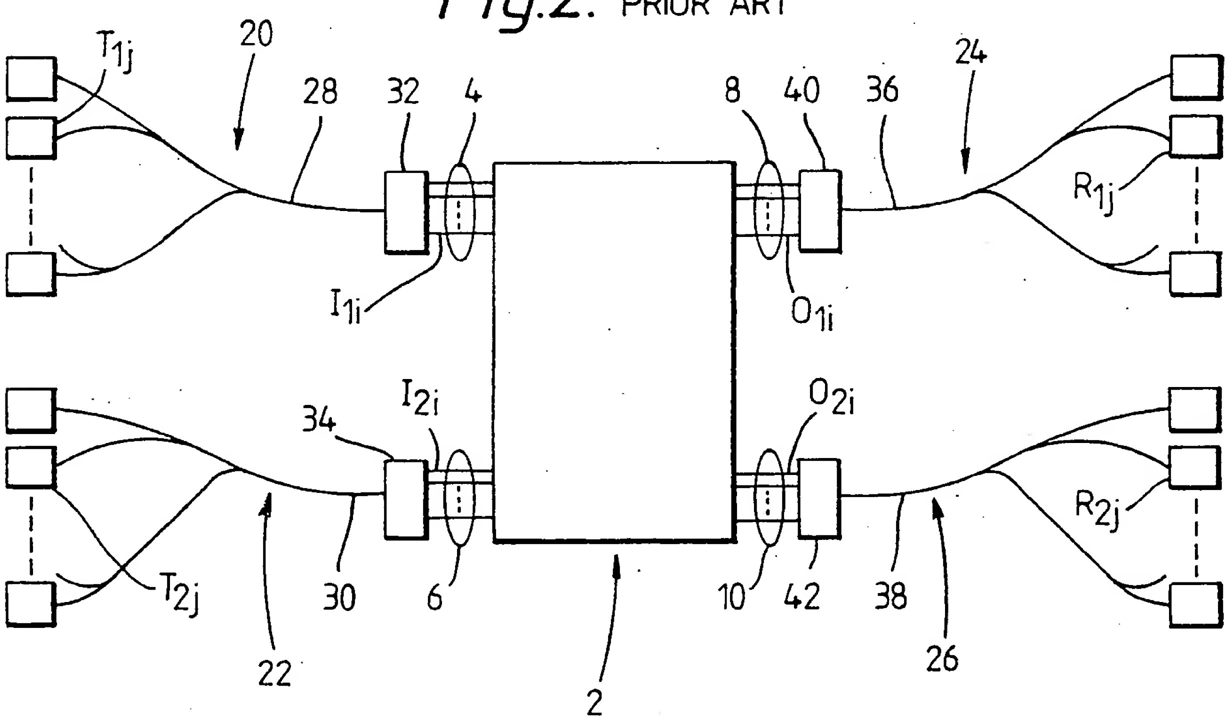


Fig.3.

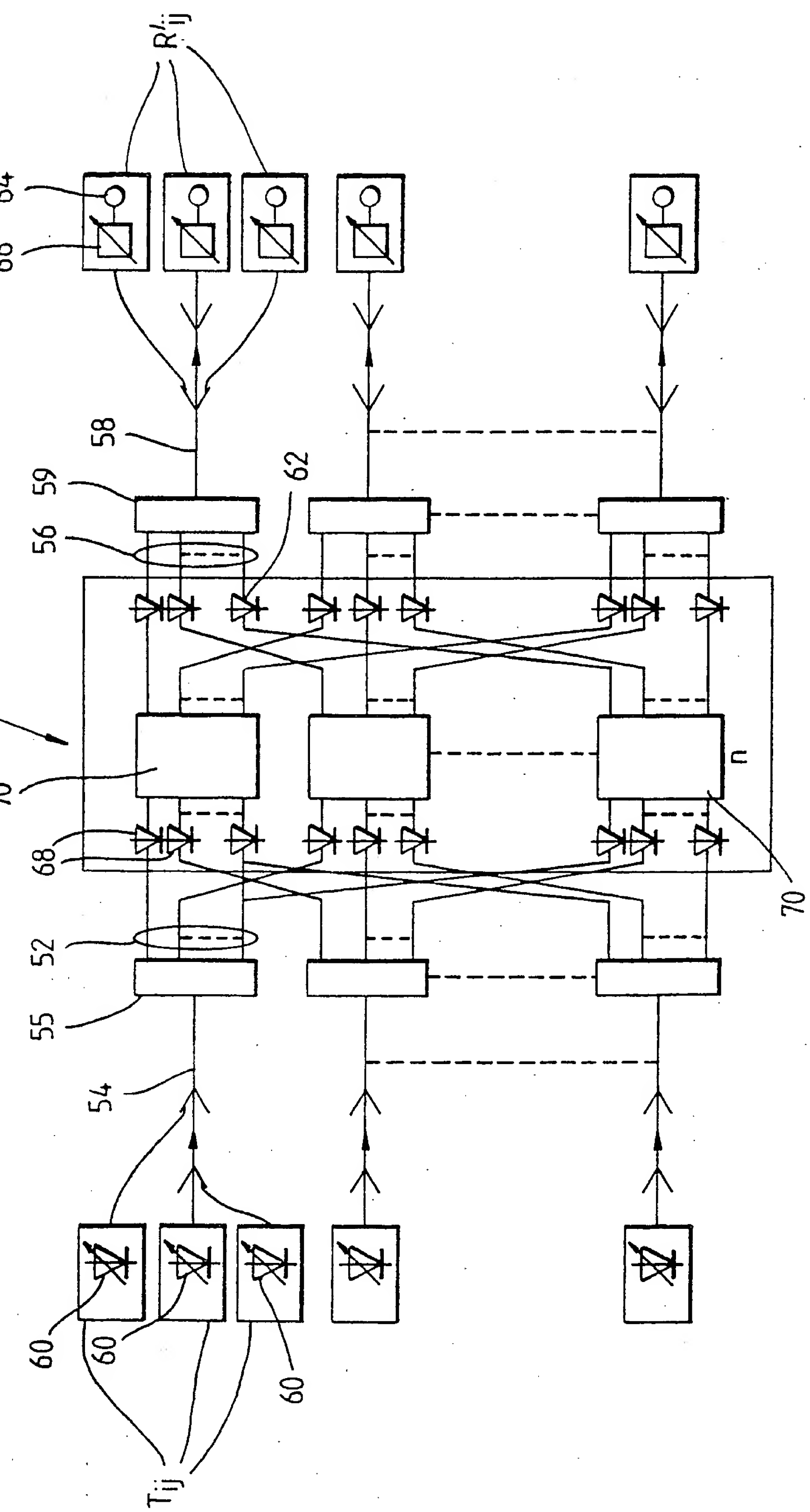
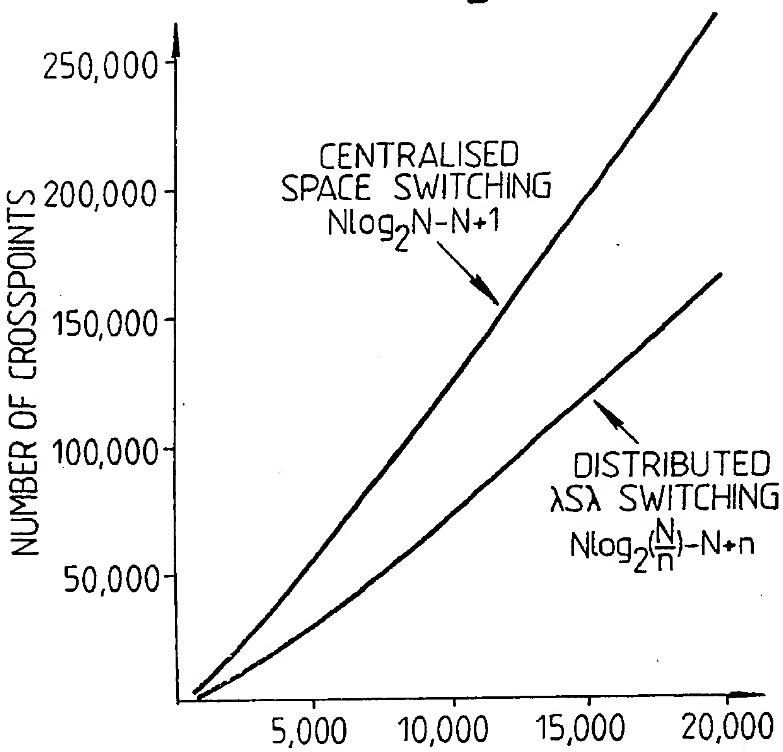
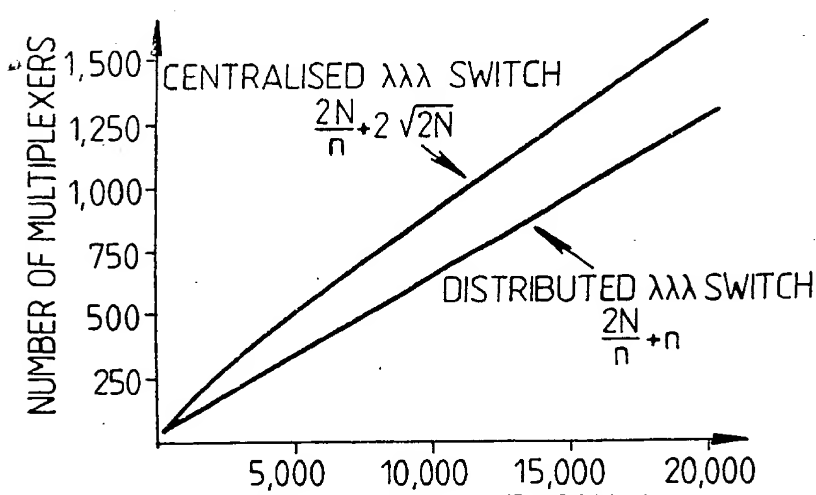


Fig.4.



OPTICAL CROSSPOINT REQUIREMENTS (PASSIVE SPLIT SIZE TAKEN AS n=32)

Fig.6.



WAVELENGTH-DIVISION-MULTIPLEXER REQUIREMENTS (PASSIVE SPLIT SIZE n=32)

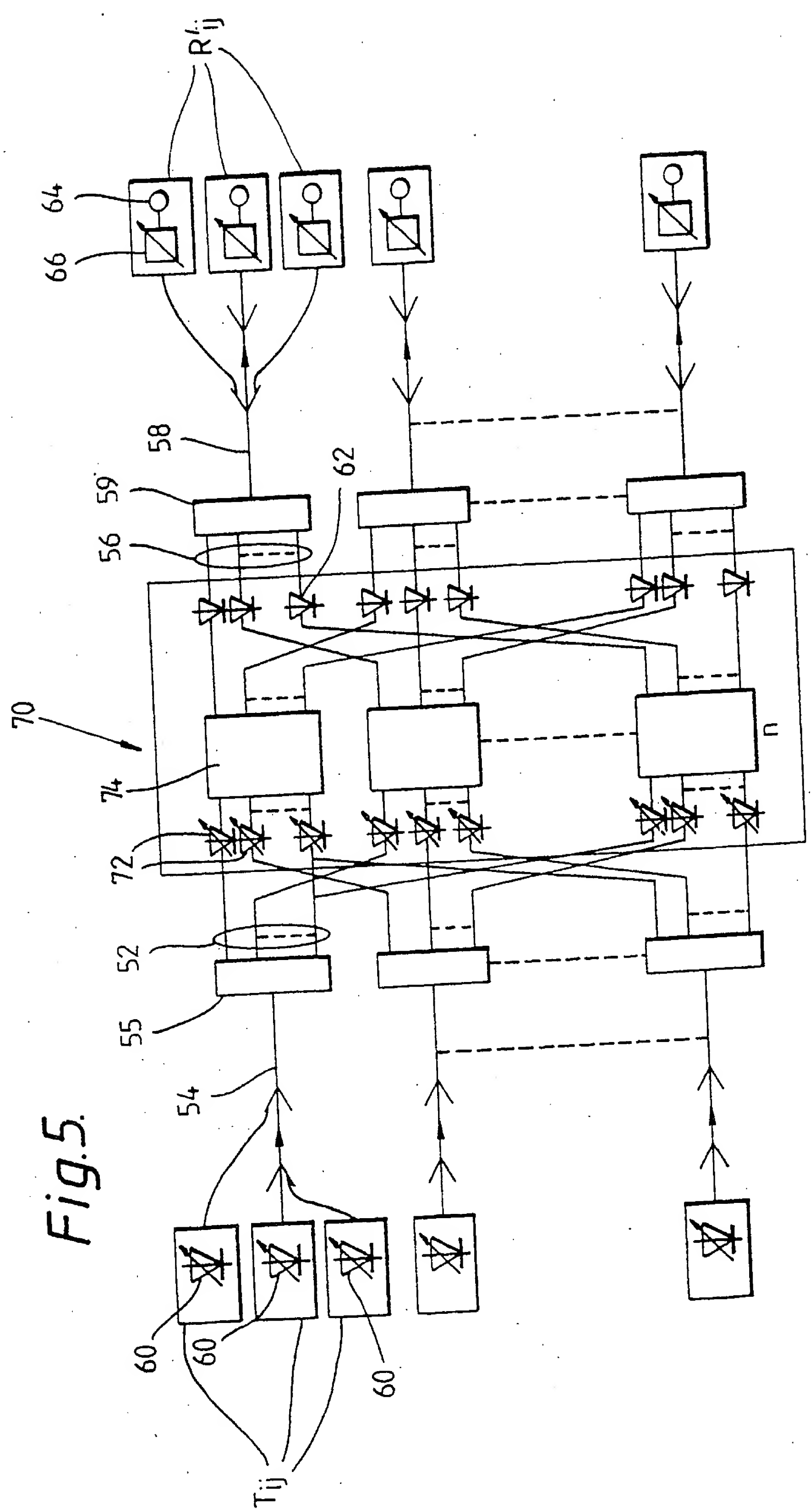
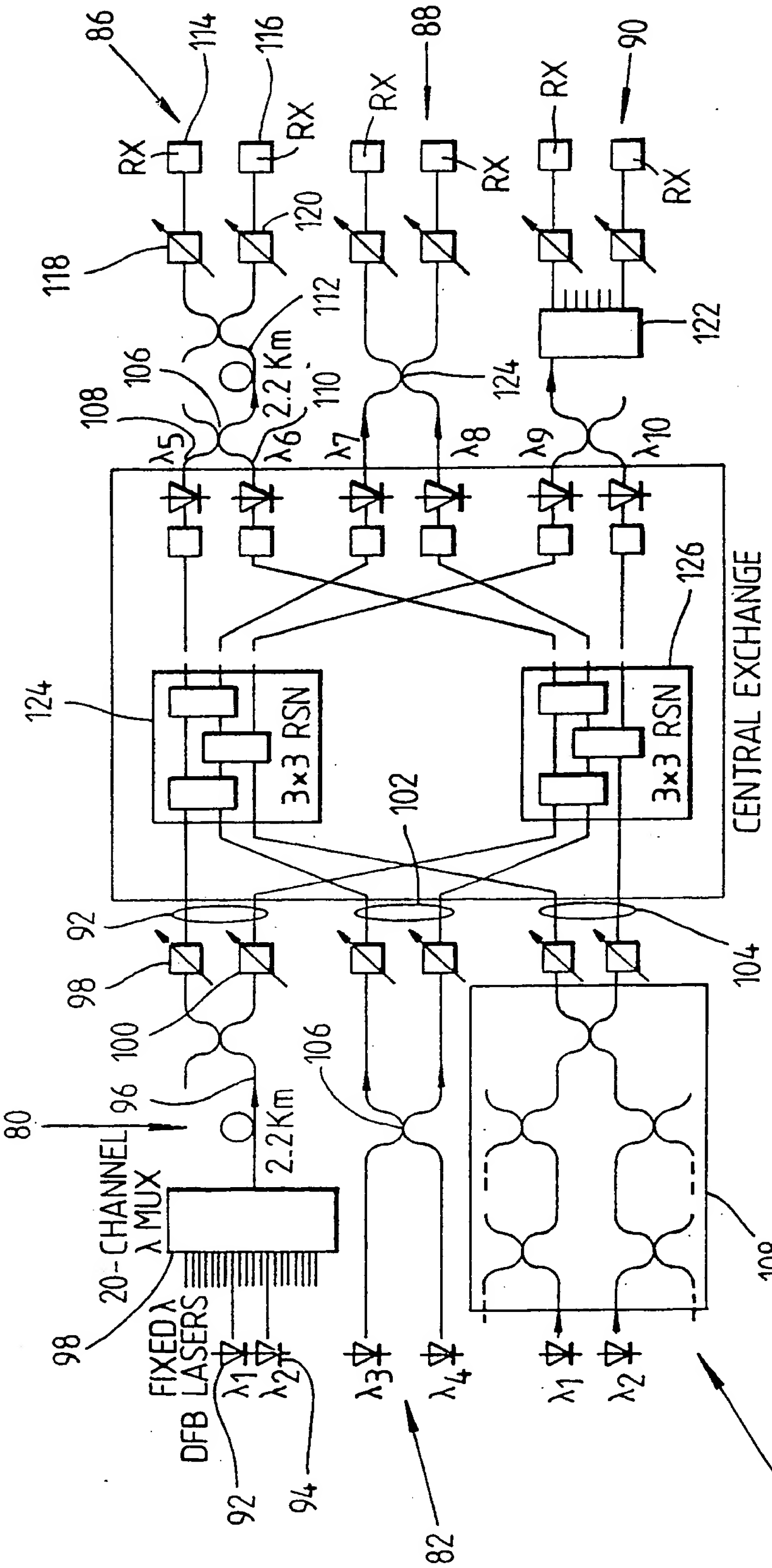


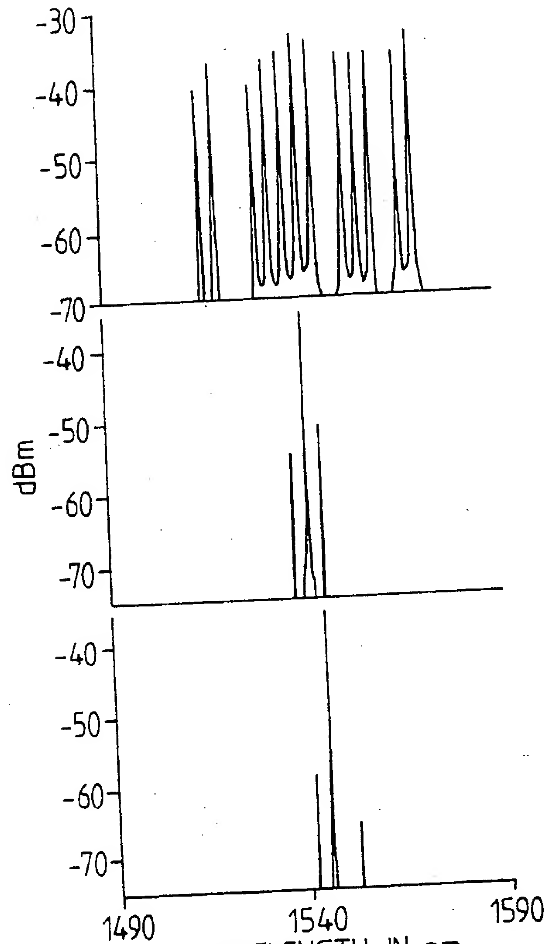
Fig.5.

Fig.7.



EXPERIMENTAL WAVELENGTH/SPACE/WAVELENGTH DISTRIBUTED SWITCHING NETWORK

Fig.8.



SELECTION OF TWO ADJACENT CHANNELS FROM A 20-CHANNEL SINGLEMODE WAVELENGTH-DIVISION-MULTIPLEXER, WITH 3.6 nm CHANNEL SPACING, 12 CHANNELS ARE OCCUPIED BY DFB LASER SOURCES, AND CHANNEL SELECTION IS BY TUNEABLE GRATING FILTER.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 90 30 1128

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	PATENT ABSTRACTS OF JAPAN, vol. 7, no. 284 (E-217)[1429], 17th December 1983; & JP-A-58 161 486 (NIPPON DENKI K.K.) 26-09-1983 * Abstract * ---	1,7	H 04 Q 3/52 H 04 B 10/00 H 04 Q 11/00
A	WO-A-8 605 649 (PAYNE) * Page 1, line 29 - page 3, line 20 * ---	1,7-12	
A	GB-A-2 043 240 (THE POST OFFICE) * Page 1, lines 37-89 * ---	7-12	
A	PATENT ABSTRACTS OF JAPAN, vol. 4, no. 44 (E-5)[526], 5th April 1980, page 164 E 5; & JP-A-55 16 584 (NIPPON DENSHIN DENWA KOSHA) 05-02-1980 * Abstract * -----	1,7	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H 04 Q H 04 B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10-04-1990	VANDEVENNE M.J.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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